
# Mars Express - NASA Project

JPL

## THE MARS EXPRESS/NASA PROJECT AT JPL

**T. W. Thompson, R. L. Horttor, C. H. Acton, Jr.,**
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**Jet Propulsion Laboratory,**
**California Institute of Technology,**
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**Lunar and Planetary Science Conference**
**17 March 2005**


# Mars Express/NASA Project
# Project Overview

**Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS)** :
- A joint NASA-ASI instrument development. NASA/JPL is responsible for Radio Frequency System (the Integrated Receiver, Transmitter, and Antenna Subsystems). ASI is responsible for Digital Electronic Subsystem, System integration, and Operations.
- MARSIS Antenna Deployment in late April to be followed by Vommissioning and key observations of the South Pole

**Science Support**: Provides for U.S. science participation in Mars Express:
- By funding U.S. Co-Investigators , Participating Scientists and Interdisciplinary Scientists on Mars Express HRSC, OMEGA, PFS, Radio Science, SPICAM, and MARSIS Experiments
- By developing NAIF-SPICE as well as MIPL Telemetry and Archiving Software that support delivery of Mars Express scientific data to PDS

**Telecom Interoperability**: Conduct Communication Interoperability Studies and design tests to ensure interoperability of NASA and ESA assets at Mars - **DONE** - Successfully demonstrated

**DSN Support**: Provide DSN Tracking support in accordance to requirements in the PSLA.

**Navigation Assurance**: Conducted Joint ESOC-JPL Navigation Campaign in Cruise - DONE

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**ASPERA 3:** Design, Construction, and Delivery of ASPERA-3 Electron and Ion Spectrometers to Swedish Institute of Space Physics. Funded under the Discovery Program.

# Mars Express/NASA Project Personnel

Mars Express/NASA Project Manager
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Mars Express/NASA Project Science Manager
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MARSIS Instrument Manager
W. T. K. Johnson (wtk.johnson@jpl.nasa.gov)

MARSIS Co-PI
Jeffrey J. Plaut (plaut@jpl.nasa.gov)

NASA Headquarters Program Executive
David Lavery (dave.lavery@hq.nasa.gov)

NASA Headquarters Program Scientist
Steve Saunders (stephen.saunders@nasa.gov)

# MARS EXPRESS MISSION EXPERIMENTS AND INVESTIGATORS

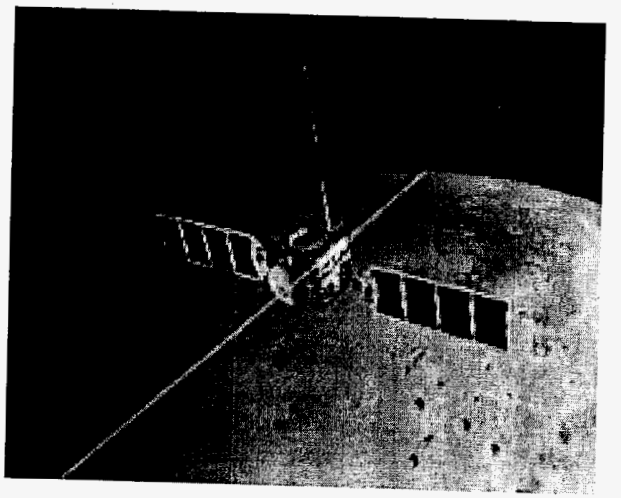
| Country | Experiment | US Hardware | PI | Co-PI | US Co-Is |
|---|---|---|---|---|---|
| Italy/US | **MARSIS**<br>Mars Advanced Radar for Subsurface and Ionospheric Sounding | Bill Johnson (JPL)/Donald Gurnett (Iowa) provides **RF Sub-systems and Sounder antenna** | Prof. G. Picardi, University of Rome | Jeff Plaut, JPL | Gurnett, Univ of Iowa<br>Stofan, Proxemy<br>Clifford. LPI (PS)<br>Farrell, GSFC (PS)<br>Leuschen, APL (PS)<br>Phillips, Wash-Univ (PS)<br>Watters, Smithsonian (PS)<br>Safaenilli, JPL (IS) |
| Italy | **PFS**<br>Planetary Fourier Spectrometer | | Dr. V. Formisano, Instituto Fisica Spazio Interplanetario | | Atreya, Univ. of Michigan |
| Sweden | **ASPERA-3**<br>Analyser of Space Plasmas and Energetic Atoms, v.3 | Discovery Program provides **Electron Spectrometer (EIS) and portions of the Ion Mass Analyzer** | Prof. Dr. R. Lundin, Swedish Institute of Space Physics | EIS PI is D. Winningham of SwRI | Sandel, UAZ<br>Curtis, UAZ<br>Hseih, UAZ<br>Kozyra, Univ of Michigan<br>Luhmann, UCLA<br>Williams, APL<br>Roelof, JHU<br>Scharber, SwRI<br>Frahm, SwRI<br>Williams, JHU |
| Germany | **HRSC**<br>High Resolution Stereo Camera | | Prof. Dr. C. G. Neukum, Freie Universitaet, Berlin | | Carr, USGS<br>Kirk, USGS<br>Duxbury, JPL (IDS)<br>Greeley, ASU<br>Head, Brown<br>McCord, PSI<br>Squyres, Cornell |
| Germany | **MaRS**<br>Radio Science Experiment | | Prof. Dr. M. Paetzold, University of Cologne | | Tyler, Stanford Univ.<br>Simpson, Stanford (TM)<br>Hinson, Stanford (TM)<br>Asmar, JPL (IS) |
| France | **SPICAM**<br>Spectroscopic Investigation of the Characteristics of the Atmosphere of Mars | | Prof. Dr. J. L. Bertaux, Service d'Aeronomy, Verrieres-le-Buisson | | Sandel, UAZ<br>Stern, SwRI |
| | **OMEGA**<br>Observatory of Mineralogy, Water, Ice and Activity | | Jean-Pierre Bibring, IAS Laboratory | | Arvidson, Wash U<br>Mustard, Brown<br>Morris, JSC |
| U. K. | **Beagle II Lander** | | C. Pillinger, Open University | | Sinha, JPL<br>Gibson, JSC (IDS) |

*Mars Express-NASA Project*

# OVERVIEW

***ESA's Mars Express Mission***

- ***Orbiter supplied by ESA***
- ***Seven Instruments from five countries and U.S.***
- ***Radar Sounder by U.S. and Italy is new***
- ***Launched on June 2, 2003***
- ***Arrived December 25, 2003***
- ***Prime mission is one Mars year***
- ***Extended mission includes an additional Mars year***



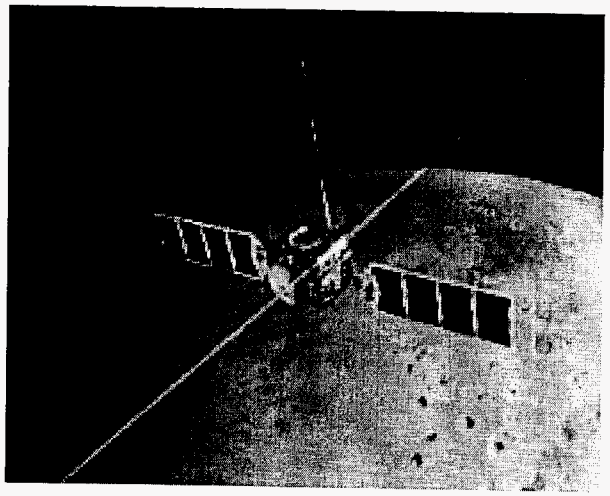
- ***NASA/JPL Contributions to Mars Express***
  - ***MARSIS Instrument***: *Radar Sounder MARSIS Managed by JPL with Antenna, Transmitter and RF Subsystems furnished by U.S. (Joint 50-50 effort with Italians)*
  - ***Science:*** *25 U.S. Investigators on European Experiments - HRSC and NAIF-SPICE Software*
  - ***DSN Tracking Support***: *Additional Downlink, Radio Science, Cruise Navigation*
  - ***Telecom Interoperability***: *Demonstrated Mars Express-MER UHF Link*
  - ***Navigation Assurance:*** *Joint ESOC-JPL Navigation in Earth-Mars Cruise*
  - ***Aspera-3***: *Electron/Ion Spectrometers funded by Discovery*

# Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) Overview

JPL

## Salient Features

- Joint NASA/JPL - ASI/Alenia Spazio Project
- JPL responsible for RF subsystem, Alenia responsible for Digital subsystem plus MARSIS & System level integration
- NASA/JPL Hardware Contributions: RX from JPL, TX from Univ. Iowa, Antennas from TRW Astro Aerospace
- Mass = 15 kg / Power = 60 W / Main Antenna 40 m dipole
- Deliver EM-Like Units to ASI - October 2000
- Deliver Flight Units to ASI - August 2001
- Flight Acceptance Review - late-2001



## Scientific Objectives

Primary - To map the distribution of water, both liquid and solid, in the upper crust of Mars.

1. Detect and map subsurface liquid water.
2. Map distribution and thickness of ice-saturated layers
3. Measure thickness, structure and properties of polar deposits.

Secondary

- Detect and map geologic units and structures in the third dimension.
- Characterize surface properties: elevation, roughness, and radar reflectivity.
- Probe the ionosphere of Mars to study the interaction of the atmosphere and solar wind.

## Measurement Capabilities

- Resolution:
  Better than or equal to 10 km lateral (footprint size).
  Better than or equal to 100 m depth.
- Coverage:
  Global at < 10 km footprint spacing.
  Polar coverage is desirable.
- Depth of water layer detection:
  > 5 km under favorable conditions.
  > 3 km under most conditions.
- Calibration:
  Surface reflectivity determination to within ±25%.

# Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) Experiment Overview

## What is it?

MARSIS is an orbital low-frequency (1.3 MHz – 5.5 MHz) sounding radar that provides echo profiles of the subsurface of Mars to several kilometers deep. It also operates in an ionospheric sounding mode (0.1 MHz-5.5 MHz) to observe the interaction of the solar wind and the upper atmosphere of Mars.

## Science Objectives:

Primary- Detect, map and characterize subsurface material discontinuities in the upper crust of Mars. These may include boundaries of: Liquid water-bearing zones / Icy layers / Geologic units/ Geologic structures

Secondary - Characterize surface properties: elevation, roughness, and radar reflectivity. Probe the ionosphere of Mars to study the interaction of the atmosphere and solar wind.

## Measurement capabilities:

Resolution:

Better than or equal to 10 km lateral (footprint size).
Better than or equal to 100 m depth.

Coverage: - Global at < 10 km footprint spacing.

Depth of water layer detection: Up to 5 km.

# Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) Experiment Overview

## How does MARSIS "Follow the Water?"

MARSIS provides the first opportunity to probe the subsurface to several kilometers deep and directly detect liquid water.

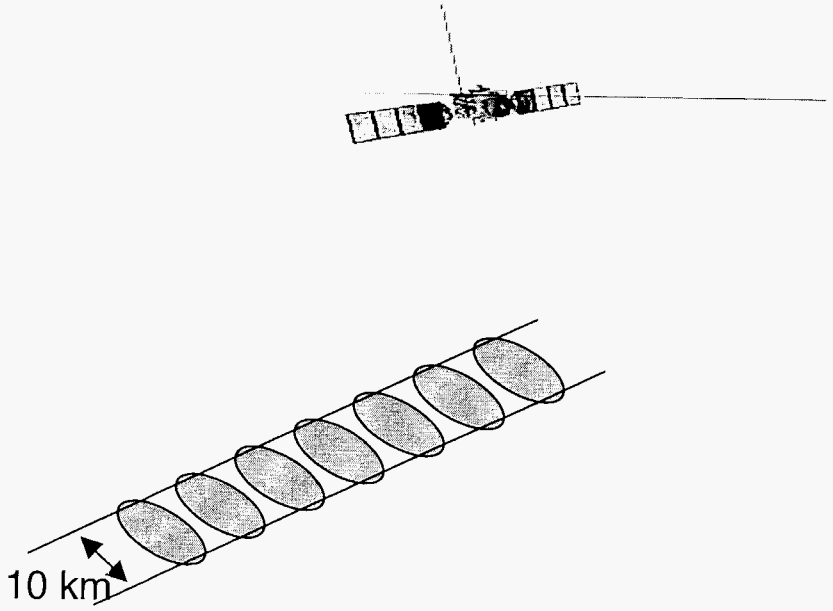
If aquifers are present in the upper ~ 3 km of the crust, we expect to see a radar signature. Liquid water provides a uniquely high contrast in dielectric properties compared with surrounding rocks.

Detecting the presence/absence of ice will be more difficult; likewise other geologic contacts, due to smaller dielectric contrasts. However, many interfaces are likely to be mapped, some of which are related to relict or current hydrologic processes.

Near-surface aquifers may be present due to active thermal processes or low-thermal-conductivity sediments. Detection of these sites could provide targets for future in situ life and water resource exploration.

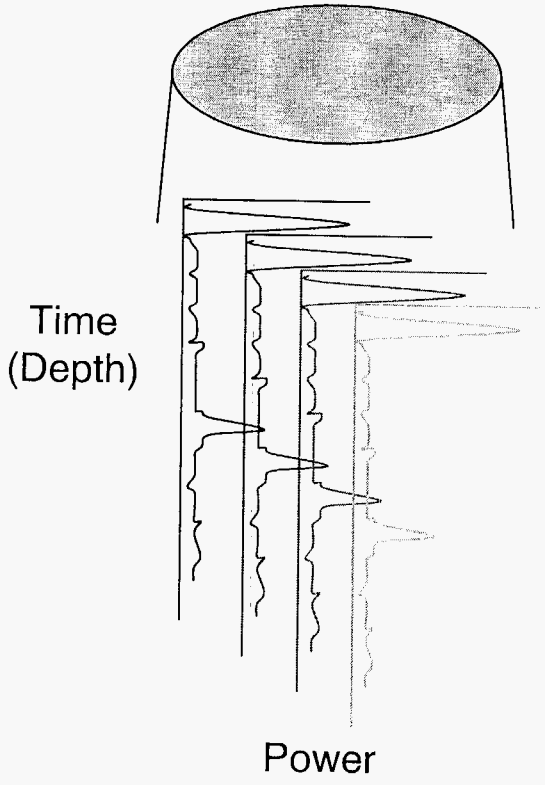
# Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) Experiment Overview

## Swath Mapping




~ 500 contiguous footprints per orbit

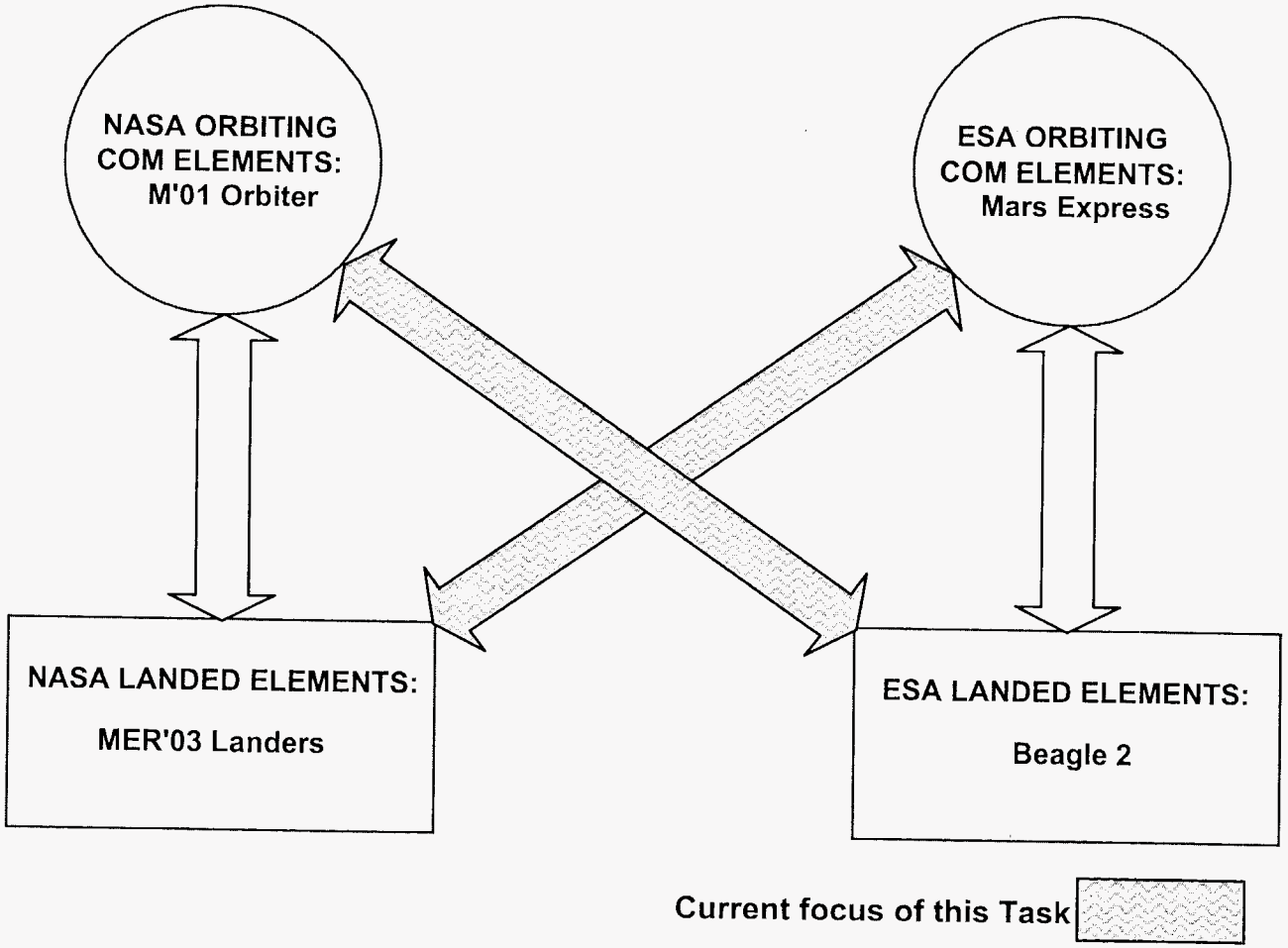
## Single Footprint




Up to 4 profiles for each footprint

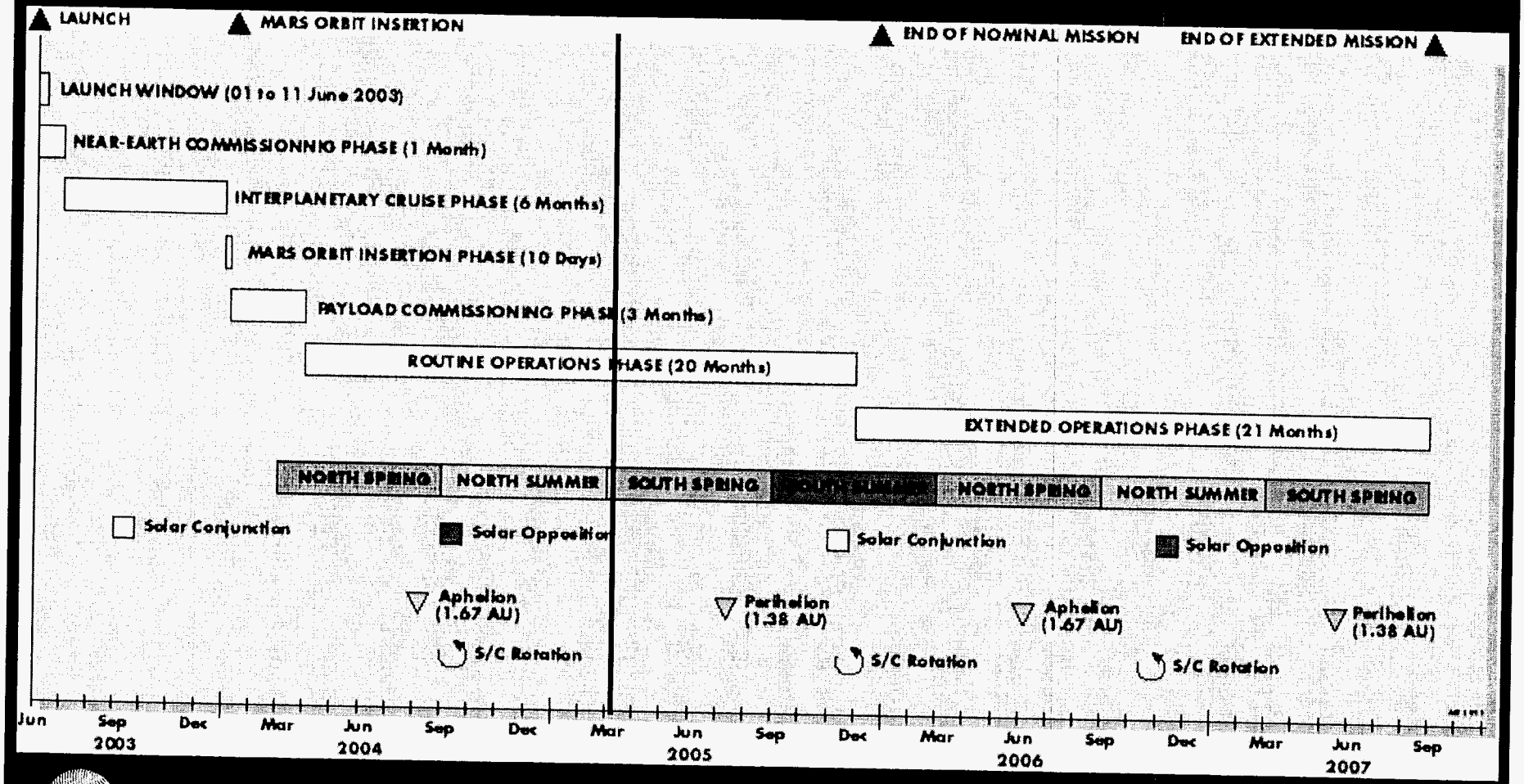
## Mars Express/NASA Project

# INTEROPERABILITY CONCEPT



# Mars Express Science Operations

## Mission Timeline

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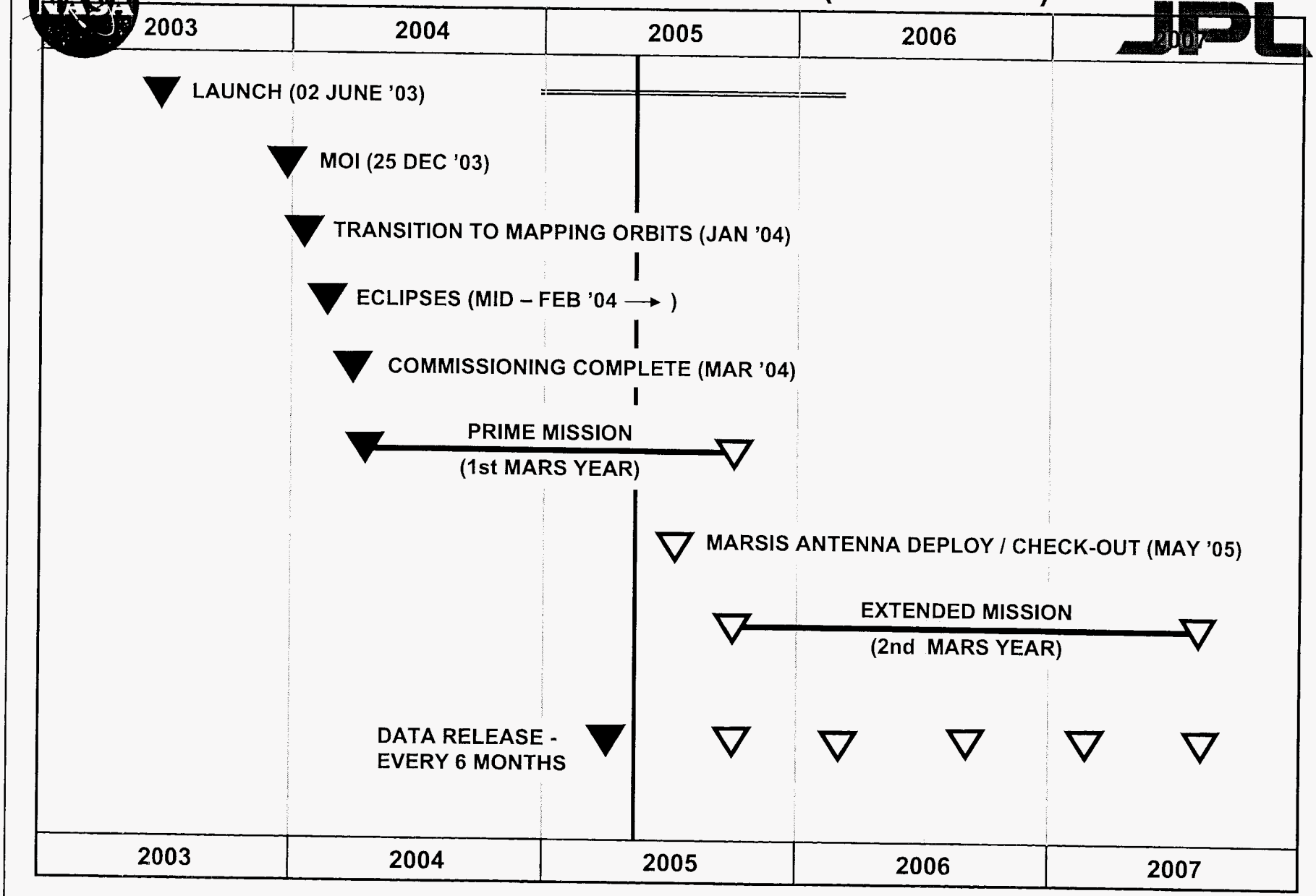
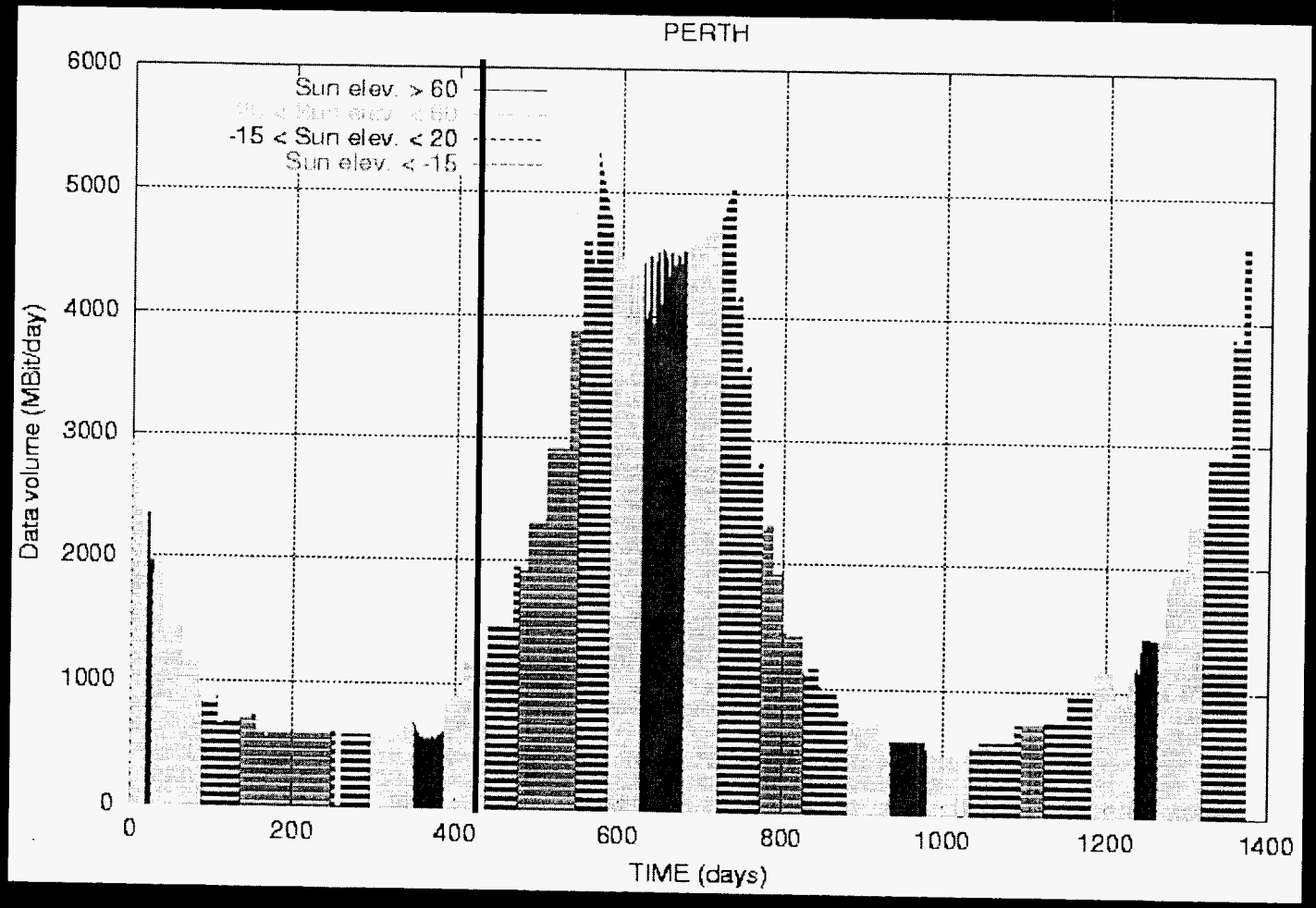
# MARS EXPRESS SCHEDULE (2003 – 2007)




Version 1 — 02 Mar '04

# Mars Express Science Operations

## Science Data Downlink

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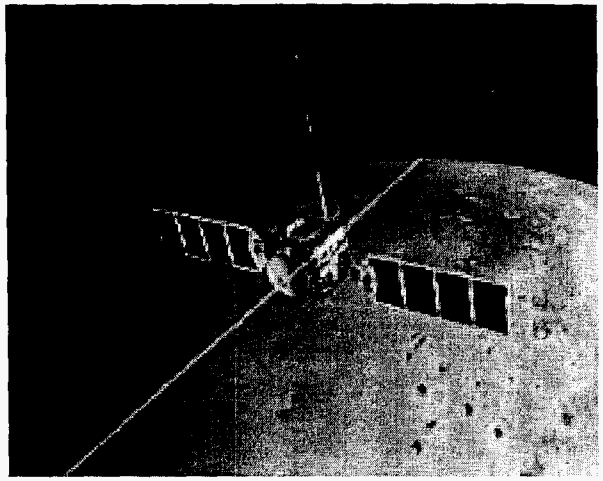

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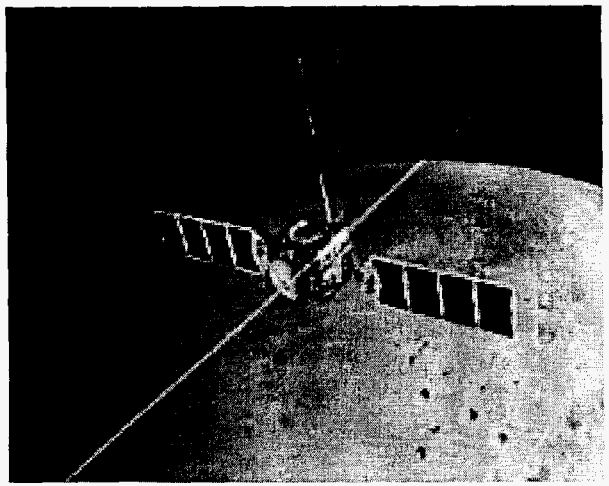

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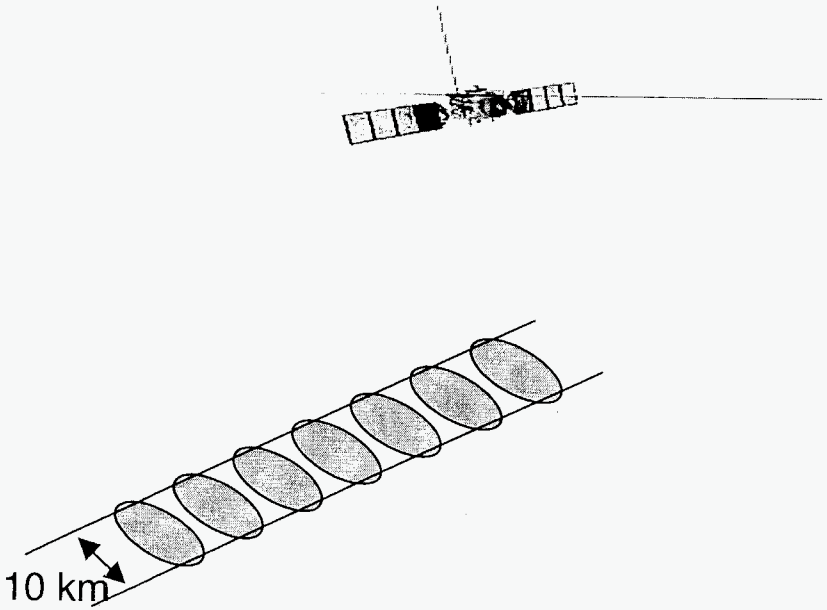
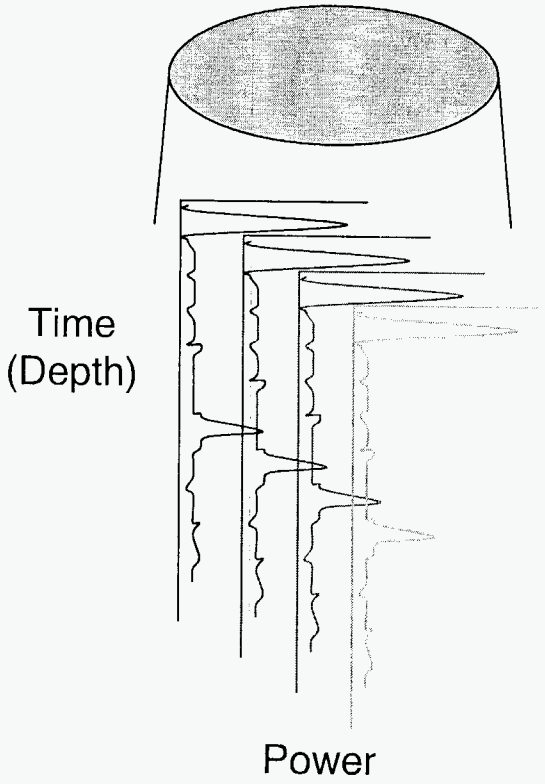



~ 500 contiguous footprints per orbit

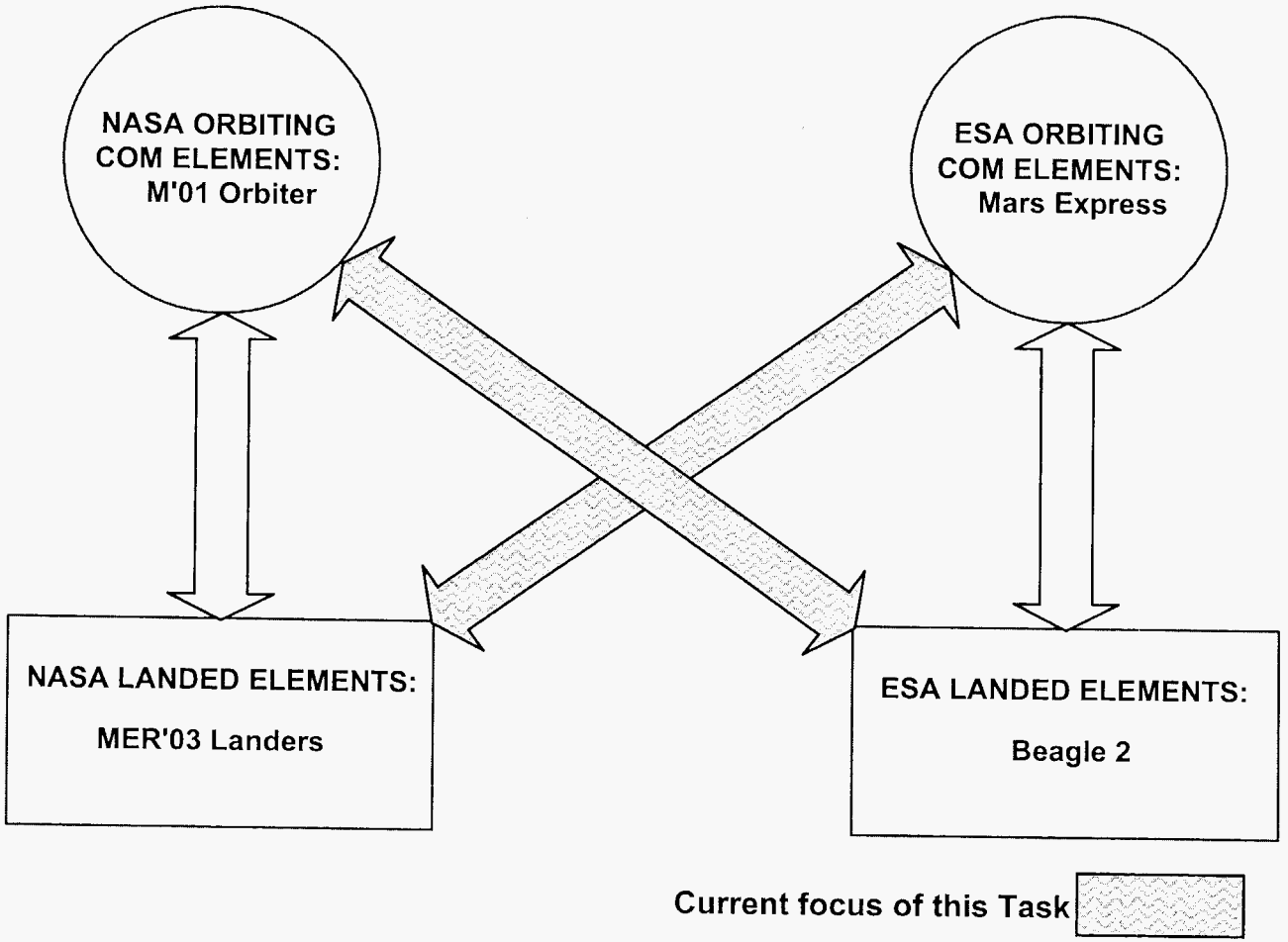
## Single Footprint




Up to 4 profiles for each footprint

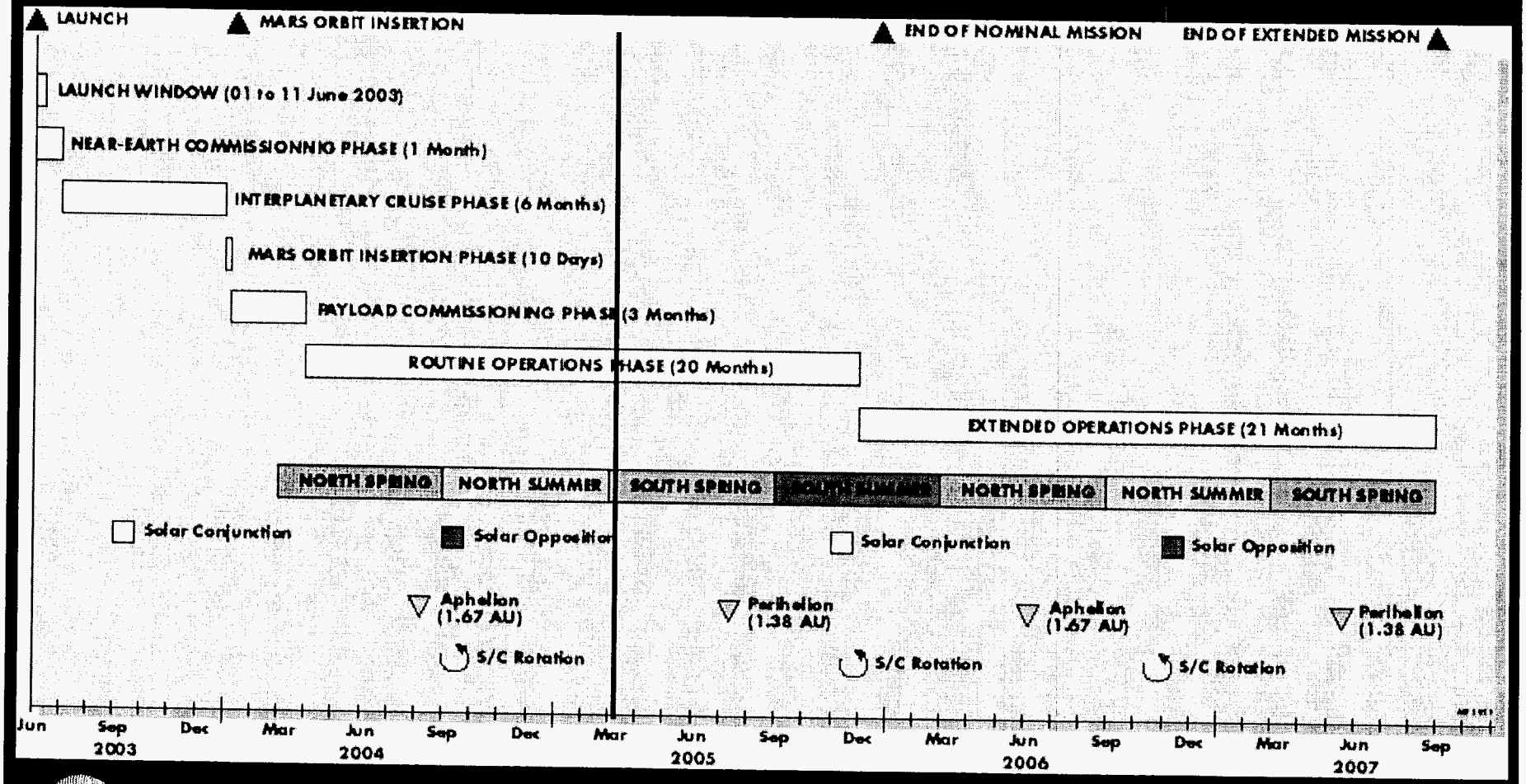
## Mars Express/NASA Project

# INTEROPERABILITY CONCEPT



# Mars Express Science Operations

## Mission Timeline

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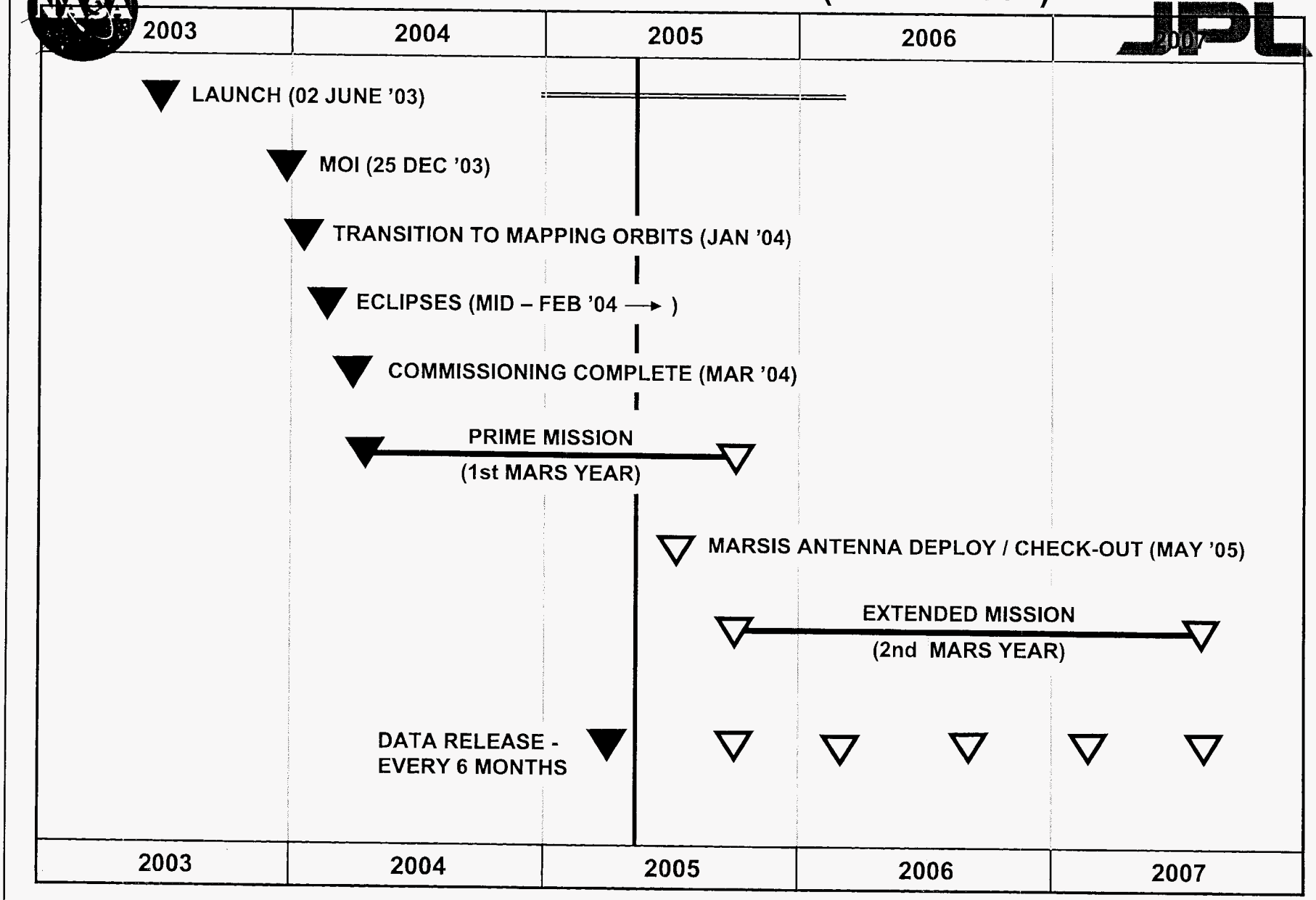
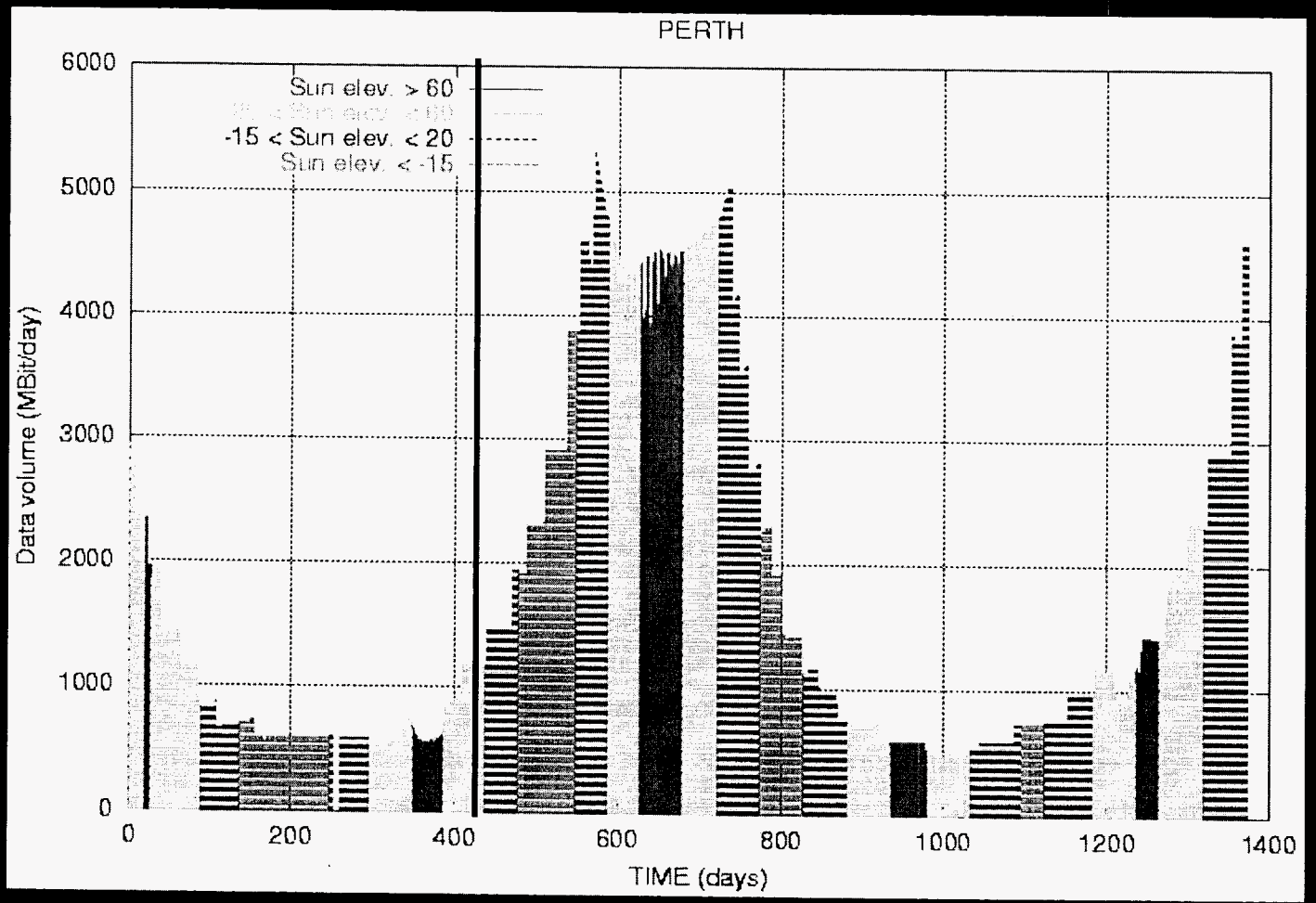
# MARS EXPRESS SCHEDULE (2003 – 2007)




*Version 1 — 02 Mar '04*

# Mars Express Science Operations

## Science Data Downlink

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